# Dust transport and deposition observed from the Terra-Moderate Resolution Imaging Spectroradiometer (MODIS) spacecraft over the Atlantic Ocean

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[1] Meteorological observations, in situ data, and satellite images of dust episodes were used already in the 1970s to estimate that 100 Tg of dust are transported from Africa over the Atlantic Ocean every year between June and August and are deposited in the Atlantic Ocean and the Americas. Desert dust is a main source of nutrients to oceanic biota and the Amazon forest, but it deteriorates air quality, as shown for Florida. Dust affects the Earth radiation budget, thus participating in climate change and feedback mechanisms. There is an urgent need for new tools for quantitative evaluation of the dust distribution, transport, and deposition. The Terra spacecraft, launched at the dawn of the last millennium, provides the first systematic well-calibrated multispectral measurements from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument for daily global analysis of aerosol. MODIS data are used here to distinguish dust from smoke and maritime aerosols and to evaluate the African dust column concentration, transport, and deposition. We found that 240 ± 80 Tg of dust are transported annually from Africa to the Atlantic Ocean, 140 ± 40 Tg are deposited in the Atlantic Ocean, 50 Tg fertilize the Amazon Basin (four times as previous estimates, thus explaining a paradox regarding the source of nutrition to the Amazon forest), 50 Tg reach the Caribbean, and 20 Tg return to Africa and Europe. The results are compared favorably with dust transport models for maximum particle diameter between 6 and 12 μm. This study is a first example of quantitative use of MODIS aerosol for a geophysical research.

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## 1. Introduction

[2] *Prospero and Carlson* [1972], *Prospero and Nees* [1977] and *Carlson* [1979] used meteorological observations, in situ data and satellite images (AVHRR) of dust episodes, to derive the first estimates of dust emission from Africa of 100 Tg of dust for a latitude belt 5°–25°N in the summer months June to August. This estimate was done before inaccuracies with AVHRR calibration were recognized and corrected [*Holben et al.*, 1990]. Owing to lack of systematic satellite measurements designed for aerosol studies, improvements in the estimates of dust emission were based mainly on models of the dust sources, emission and transport [*Tegen and Fung*, 1994; *Prospero et al.*, 1996; *Ginoux et al.*, 2001]. With the launch of the first Moderate Resolution Imaging Spectroradiometer (MODIS) instrument at the end of 1999, quantitative and systematic measurements of dust transport are possible [*Gao et al.*, 2001; *Kaufman et al.*, 2002] and presented here for the Atlantic ocean.

[3] The constant flux of dust across the Atlantic Ocean is of considerable interest. In the last 10 years the citation index reports 500 papers about or related to Saharan dust, and shows an exponential increase in the publication rate, starting from the early works of Prospero and Carlson in the 1970s (see Figure 1). Iron contained in aeolian dust was shown to be an important micronutrient for ocean phytoplankton, which could contribute to fluctuation of $CO_2$ on climatic timescales [*Martin et al.*, 1991] and contribute to climate variations. *Erickson et al.* [2003] measured, using satellite data, the effect of dust deposition on ocean productivity. Over the millennia, dust was suggested to be the main fertilizer of the Amazon forest [*Swap et al.*, 1992]. Desert dust, now considered to originate mainly from natural source [*Tegen et al.*, 2004] interact with solar and thermal radiation, thus can modulate the Earth radiation balance in response to changing climate conditions [*Prospero et al.*, 2002], i.e., changes in

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